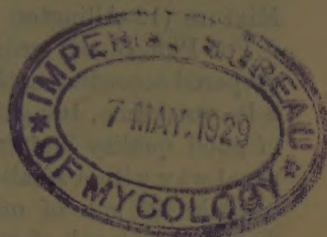


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CONTROL OF APPLE SCAB ON ALLINGTON PIPPIN AND NEWTON WONDER BY TWO TYPES OF BORDEAUX MIXTURE

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IN 1927, spraying experiments were carried out in one of the apple plantations at the South-Eastern Agricultural College, Wye, Kent, with the object of determining (a) whether the prevention of scab could satisfactorily be secured on the varieties Allington Pippin and Newton Wonder by spraying with ordinary Bordeaux Mixture; and (b) whether a Bordeaux Mixture made with ready-prepared slaked lime (*i.e.*, commercial hydrate of lime or calcium hydrate) was equal in fungicidal power to the usual one in which lump quicklime is freshly slaked at the start.

The trees of Allington Pippin and Newton Wonder selected comprised the whole of a small plantation. They were half-standards (on Crab stocks) and had been planted in 1913, both varieties being at 28 feet square. The height of the Allington Pippin trees was 12-15 feet and their spread 21 feet; that of the Newton Wonder trees was 15 feet and their spread 24 feet. There were 42 trees of the Newton variety and 36 of the Allington. The plots were arranged in such a way that three control blocks, each consisting of 9 trees to be left unsprayed, were distributed in different parts of the plantation. These plots were numbered 1, 2, and 3, and they included altogether 12 trees of Allington Pippin and 15 of Newton Wonder. The remaining trees in the plantation were then divided into two plots: A, to be sprayed with hydrate of

lime Bordeaux Mixture (12 Allington Pippin and 12 Newton Wonder), and B, to be sprayed with ordinary Bordeaux Mixture (12 Allington Pippin and 15 Newton Wonder).¹

For Plot B, the ordinary quicklime Bordeaux Mixture was prepared according to the formula 8-8-100 (8 lb. copper sulphate, 8 lb. quicklime, 100 gal. water). The freshly burnt quicklime, of good quality and free from ashes, etc., was slaked in the usual way with a small quantity of water and was then diluted to make 92 gal. of milk of lime. The copper sulphate was dissolved in 8 gal. of water and was then poured into the tank containing the milk of lime. The resulting Bordeaux Mixture was well stirred and carried at once to the spraying machine. As regards the hydrate of lime Bordeaux Mixture for Plot A, owing to the chemical difference between this form of lime and quicklime, it is necessary to use more of the former— $1\frac{1}{2}$ lb. in the place of every 1 lb.; the formula thus becomes 8-12-100. The method of making is similar in both cases, except that the hydrate of lime, being already in the slaked form, requires only to be stirred up with a little water to form a thin cream, and it is ready to be diluted to 92 gallons and then to have the copper sulphate added.

Prepared hydrate of lime (calcium hydrate) can now be obtained as a fine dry powder containing 95 per cent. of hydrate, and it costs, as sent out in paper-lined bags, about 50s. per ton on rail. A minimum hydrate content of 90 per cent. should be insisted upon by the buyer. The material used was obtained from the Callow Rock Lime Co., Shipham, Winscombe, Somerset. It can also be obtained from the Snodland (Kent) Works of the Cement Marketing Company and from the Buxton Lime Company. It was found that, if the paper-lined bag was closed at once after the required quantity of hydrate of lime had been weighed out, there was very little transformation of the hydrate into carbonate during the period between the first and the third sprayings. This point is important, because hydrate of lime changes into the carbonate on exposure to air, which normally contains some carbon dioxide, and then becomes unsuitable for the preparation of Bordeaux Mixture. The bag must therefore not be left open, but the paper lining should be carefully closed again and the bag fastened up; an empty sack or two thrown over the bag of hydrate of lime will also help to keep out the air.

The first spraying was carried out on May 2, 1927. The

¹ One Newton Wonder tree had recently been replaced by a small tree (about 6 ft. high) which was too young to bear more than a negligible crop.

hydrate of lime Bordeaux Mixture was applied to Plot A at the start. A small hand-spraying machine, with pump and tank, required one man to work the pump, maintaining a pressure of 75 lb., and one man carrying buckets from the mixing tub to replenish the tank as it was moved about in the plantation. The application of the spray was performed by two men, each using a 6 ft. rod with a "Mistifier Junior" nozzle fitted with the smallest aperture disc. Each rod was attached to a 60 ft. length of rubber hose. The weather was fine; and, with no more than an occasional faint breeze, ideal conditions obtained for the work. The quantity of hydrate of lime Bordeaux Mixture used in spraying Plot A was 61 gallons, or $2\frac{1}{2}$ gallons per tree, the work being done carefully and the leaves well covered.

At the time of spraying Plot A, scab spots were found on a few leaves of all the Allingtons; the trees were in the "pink bud" stage, with one or two blossoms already open here and there in a few of the trusses. On the Newtons single spots of scab were found on each of a very few leaves, but only on some of the trees. This variety was more backward, being in the "close pink bud" stage.

Plot B was sprayed next, on the same day (May 2), with ordinary quick-lime Bordeaux Mixture, after the tank and pipes had been washed out with water. The amount of mixture used on this plot was 62 gallons. Scab was found here on a few leaves of every Allington tree, but in the Newtons it was so rare that only one spot was found on each of two trees.

As regards the condition of the unsprayed (control) plots 1, 2, and 3, at this date, many leaves of the Allingtons showed scab, and a few were marked with brown areas on both surfaces where the fungus had killed the underlying tissues. On the Newtons, however, scab was rare. One tree of Allington Pippin (Plot 2) was especially noticeable, owing to the presence of numerous one-year-old shoots which remained. Many of these were covered with scab pustules.

The second spraying was carried out on May 23. The weather was sunny but cool, and there was only a suspicion of a breeze during the spraying of Plot A, which was done first. Later, however, when spraying was in progress on Plot B, the wind increased and became gusty, with intervals of complete calm. Plot A received 67 gallons and Plot B about 65 gallons. At this date there was a growth of 9 inches of new wood on the Allingtons, with as many as 8 new and expanded leaves on each shoot. Several of the older leaves showed brown,

dry, dead areas, $\frac{3}{8}$ in. diameter, either at the apex or at the margin. It was at first thought that this might be an injury resulting from the first application of the spray, but the scab fungus was found above or below each spot. The fungus was producing an abundance of spores on many of these older leaves, and a rather severe early attack was undoubtedly in progress. The more recently expanded leaves on the young wood, although unsprayed, showed no signs of scab—perhaps owing to the dry weather of the preceding few weeks. The petals of the Allington blossom had fallen, but a few remaining flowers could be seen high up in the trees. On the Newtons a growth of 7 inches of new wood had taken place, and as many as 7 new leaves were expanded on these fresh shoots. A small amount of scab was present on the oldest (sprayed) leaves, but brown, dead patches caused by the fungus were rare, and no more than two were seen on any one tree. As with the Allingtons, the leaves which had expanded after the first application were found not attacked. There was no spray injury or leaf fall in either variety.

As regards Plot B, which was sprayed next (on the same day), both varieties were exactly as described for Plot A with respect to new growth, immunity of the fresh foliage from scab and absence of spray injury; also with respect to intensity of scab attack, except that, in Plot B, the attack on Newton Wonder was even less than it was on that variety in Plot A.

In the control plots 1, 2, and 3, a general and rather severe attack was developing on the older leaves of the Allingtons; there were large spreading patches of scab on both surfaces, and sometimes brown, dry areas showed where the leaf had been killed through from one surface to the other. These were most commonly situated at the margin. A few of the older leaves were completely covered with scab, and many were puckered. The new foliage on the young wood was not attacked. As regards the Newtons, a few of the older leaves on every tree showed a dry, brown area at the apex. From this the scab fungus was spreading over the remaining healthy leaf surface in widening zones. As in Plots A and B, the young foliage on the new wood was not attacked. After examination of the trees in these unsprayed plots, where large dendritic patches of scab occurred on the leaves, it was evident that the result of spraying the trees in Plots A and B had been to check the development of a severe attack.

The third application was made on June 13, Plot A being sprayed first and Plot B about an hour later. The

day was dull, cloudy, and calm, except for an occasional gusty breeze. Fifty-eight gallons of hydrate of lime Bordeaux Mixture were used on Plot A and 60 gallons of ordinary mixture on Plot B. On the Allingtons, 6 to 8 inches of new wood, bearing five to seven fresh leaves, had grown since May 23. The Allington apples were much more numerous than the Newton and showed greater variation in size. A few spots of scab were seen on the oldest leaves, but the fungus had apparently been killed by the former sprayings. There was no scab on the new, unsprayed foliage, and the heavy crop of small apples was quite clean. Traces of a brown coloration, thought to be incipient russetting, were seen occasionally on the fruit, and very minute cracks (visible with a lens) were associated with it.

The new wood on the Newtons had grown a further 7 inches since the previous spraying, and on this there were four to six fresh leaves; these were green and contrasted with those lower down which were covered with the bluish spray deposit. By this date the largest Newton apples had grown to a diameter of 1 in., and it was noticed that a few of these larger fruits were brown on one side, and minute cracks were visible with a lens. There appeared no doubt that this was russetting in its earliest stage, and it was most frequently, although not always, in parts of the tree which, judging by the very blue colour of the foliage, had been sprayed heavily on the previous occasion. There was, however, no fruit drop and no injury to the leaves.

In the unsprayed (control) plots, 1, 2, and 3, there was no russetting of the fruit in either variety. On the Allingtons, a very few apples showed as many as a dozen minute spots of scab. The fungus also occurred on brown, dead spots at the tips of the oldest leaves (often those surrounding the fruit trusses) and could be seen spreading over the surfaces of the leaves from these spots. The youngest foliage on the upper part of the new growth (leaders and breastwood) was not attacked. Thus, it was only rarely that scab was found to have progressed as far as the fifth or sixth leaf from the base of a shoot measuring 15 in. and bearing as many as 11 or 12 leaves—in spite of the fact that the fifth or sixth leaf must have been exposed to infection for longer than three weeks. On the Newtons, the new wood had grown to a length of 13 in. and bore 12 fresh leaves. Scab was only rarely found, and then it occurred on and near the brown, killed patches at the tips and margins of the older leaves. At that date, the

disease was not threatening, and was apparently making no progress.

In Plot B, the Allington fruit showed slight spray damage, which was less conspicuous than in the Newtons. The foliage was uninjured and healthy, except that occasionally spots of scab occurred on a few older leaves on brown, dead areas. The Newton apples, like the Allingtons, showed the early stages of russetting in the same manner and to the same extent as in Plot A. This was not always found close to foliage which had obviously been heavily sprayed, and it was roughly estimated that not more than 5 per cent. of the apples were thus affected. No scab was found on the leaves or fruit of Newtons in Plot B. As regards spray injury to the foliage, on some of the larger branches there were three or four leaves of a pale yellow-green colour which were about to fall. There was no purple spotting of the foliage, and no leaves had fallen to the ground.

During the abnormally wet weather which prevailed in the succeeding months, the scab fungus found conditions suitable for a rapid and overwhelming attack on the leaves and fruit in the unsprayed plots. The extent of it could be seen while the crop was still on the trees, and, by comparison of the apples on the sprayed and unsprayed trees, it was evident that both Bordeaux Mixtures had provided adequate protection.

The Crop Graded for Scab.—The crop was very heavy in all the plots, and was picked on October 8, being graded by hand² for the amount of scab present. The system of grading adopted was as follows: Grade 1 consisted of apples free from scab³; Grade 2, of those apples on which scab spots were few or many, but which were not unmarketable; Grade 3, of apples which were so cracked or disfigured by scab as to be unmarketable.

The total crop of Allingtons was 4 tons, 2 cwt., and of Newtons, 4 tons, 7 $\frac{3}{4}$ cwt. From each plot, the number and also the weight of apples in every grade was ascertained, and the results are summarized in Table I. Taking first the unsprayed (control) trees, it will be found that the incidence of disease was very considerable in all three

² All the grading was carried out by the same two persons.

³ Whilst from the commercial standpoint these apples were free from scab, as many as three very minute spots on an apple (each not larger than the head of a pin) were not considered sufficient to reduce that fruit to the level of Grade 2. Such cases were numerically very small.

plots.⁴ The Allingtons in them, taken together, yielded 93 per cent. by weight⁵ of scabbed apples, *viz.*, 80 per cent. in Grade 2, and 13 per cent. in Grade 3; only 7 per cent. of the crop was scab-free (Grade 1).

TABLE I.

Plot and treatment	Variety	No. of trees	No. of apples picked	Percentage No. of apples in grade			Weight of apples lb.	Percentage weight of apples in grade		
				1	2	3		1	2	3
A. Hydrate of lime Bordeaux	Allington	12	17720	89	11	0	3362	88	12	0
	Newton	12	9985	88	12	0	2524	88	12	0
B. Quicklime Bordeaux ..	Allington	12	15094	88	12	0	2841	88	12	0
	Newton	15*	15319	87	13	0	3807	86	14	0
1, 2, & 3, taken together. Control (unsprayed)	Allington	12	16782	6	78	17	2973	7	80	13
	Newton	15	16388	14	79	7	3490	14	80	6

* See footnote, p. 227.

The Allingtons sprayed with the two Bordeaux Mixtures—whether made with quicklime or with hydrate of lime—gave no less than 88 per cent. of scab-free apples. In the unsprayed plots, as have been mentioned, only 7 per cent. of the fruit was clean. Further, whilst 13 per cent. of the unsprayed Allingtons were so scabbed and cracked as to be unmarketable, no apples at all were thus affected on the trees sprayed with ordinary quicklime Bordeaux Mixture, and only one apple in a thousand occurred in this unmarketable Grade 3 in the Allingtons sprayed with hydrate of lime Bordeaux Mixture.

Newton Wonder in the three control (unsprayed) plots taken together, yielded 86 per cent. of scabbed apples, *viz.*, 80 per cent. in Grade 2, and 6 per cent. in Grade 3; only 14 per cent. of the fruit was scab-free. The Newtons sprayed with hydrate of lime Bordeaux Mixture gave 88 per cent. of scab-free

⁴ It must be remarked that all the plots were used in 1926 for a similar series of spraying experiments. Owing to the failure of the crop in that year, the results of the spraying as regards control of scab on the fruit could not be ascertained. As has been pointed out previously (Goodwin, W., and Salmon, E. S., "Notes on Two Fungicides: Sulphur and Bordeaux Mixture," this JOURNAL, XXXIV, 517-528, September, 1927), it was observed that the foliage on the unsprayed plots became severely infested with the scab fungus, while that on the sprayed plots remained clean. It is necessary, therefore, to bear in mind the possible cumulative effects of spraying or not spraying, when considering the striking results obtained in 1927 on these plots and described in the present paper.

⁵ As will be seen by reference to Table I, the percentages according to number approximate very closely to those according to weight.

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both leaves and fruit. Consequently, it is in such seasons that the preventive effects of Bordeaux Mixture are shown to the full. The grower who has everything ready so that he can spray with home-made Bordeaux Mixture at a few hours' notice, on such fine days as do occur in a wet May or June, can confidently expect to reap his reward.

In conclusion, it must be emphasized again that in home-made Bordeaux Mixture apple growers have a sure protection against scab. Scientific experiments in this country have proved that on certain varieties, *e.g.*, Bramley's Seedling, Allington Pippin and Newton Wonder, Bordeaux Mixture (when home-made) can be used with perfect safety and success. At the present time, a considerable quantity of apples of these varieties, heavily infested with scab, are put on the English market, and compare very unfavourably with the clean, sprayed fruit imported from overseas parts of the Empire and from the United States. Growers in this country, by failing to control scab, on varieties such as these, by intelligent spraying, are not taking advantage of the results offered by modern research.

Summary.—(1) Similar plots of trees of Allington Pippin and Newton Wonder were sprayed three times with two kinds of Bordeaux Mixture:—A, made with prepared, slaked lime (hydrate of lime or calcium hydrate), and B, made, as is ordinarily done, with lump quicklime. The fungicidal powers of the two mixtures proved to be identical and eminently satisfactory.

(2) Three control (unsprayed) plots were left adjoining those sprayed. The attack of the scab fungus during the wet summer of 1927 was very severe, as shown by the amount of this disease on the crop when hand-graded. The percentage by weight of scab-affected apples was 93 in the Allingtons (total crop, 12 trees, unsprayed, $1\frac{1}{4}$ tons) and 86 in the Newtons (total crop, 15 trees, unsprayed, $1\frac{1}{2}$ tons).

(3) The percentage by weight of scab-affected apples in the sprayed plots was as follows: Allington Pippin, Bordeaux Mixture A, 12; Bordeaux Mixture B, 12; Newton Wonder, Bordeaux Mixture A, 12; Bordeaux Mixture B, 14. The total crop (sprayed) was $2\frac{3}{4}$ tons of Allington Pippin (24 trees) and $2\frac{3}{4}$ tons of Newton Wonder (27 trees).

(4) No appreciable leaf scorch was caused on either variety by the spraying. Russetting of the fruit occurred to a slight extent, but was appreciable in only 2.5 to 3.0 per cent. of the Allington and 0.2 to 0.6 per cent. of the Newton variety.